A PORTABLE LABORATORY FOR THE JUNIOR HIGH SCHOOL

HAROLD E. BORG

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Submitted in partial fulfillment of the
requirements for the degree of Master of
Arts in the Graduate School of
Florida Southern College

1949

Florida Southern College

A PORTABLE LABORATORY FOR THE JUNIOR HIGH SCHOOL

by

HAROLD E. BORG

Written Under the Direction of
Professor James Gordon Ogden, Jr.

2/8/49
Date

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The undersigned members of the reading committee of Harold E. Borg have examined his project, A Portable Laboratory for the Junior High School, and recommend its acceptance.

S. T. Fastinger

R. S. Kiser

Representatives of the
Graduate Committee

2/12/49

Date of Submission to the
Chairman of the Graduate
Committee

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CHAPTER I

PRESENTING THE PROBLEM

__General__ __Statement__. The purpose of this project is to develop a portable laboratory whereby the teaching of general science in a junior high school can be improved.

__Specific__ __Problem__. Specifically the project entails (1) designing and preparing drawings for the manufacture of a special portable demonstration desk and (2) determining the types of appliances and the kinds of supplies which are to be used in conjunction with the desk.

__Definition__ __of__ __Terms__. The term "portable laboratory" as used herein means the complete unit contained in a special demonstration desk mounted on casters so that it can be moved readily from one room to another. This demonstration desk will have:

1. Facilities for bottled gas and electricity;
2. Special service fittings for the apparatus included in the desk; and
3. Special drawers or cases for the storage of the apparatus and supplies selected.

__Delimitations__. Time will not permit the actual construction of the portable laboratory; however, in designing and preparing the drawings, all precautions will be taken to make them as accurate, usable, and economical as possible.

In selecting the apparatus and supplies for the demonstration desk the following factors are considered:

1. The content and continuity of the Florida State Adopted Science Textbooks.

2. The most practical experiments which involve only the simplest materials.

3. The cost which should be within the price range of the average school.

Basic Hypotheses. Study has revealed that general science in the junior high school is not being as effectively taught as it could be because adequate and practical demonstration equipment has not been provided.

It is contended that if suitable demonstration equipment is made easily available for use by the science teacher, more effective teaching would result.

The Need for the Study. Research and investigation have revealed that general science is, for the most part, ineffectively taught in the elementary and junior high schools. This ineffectiveness can, to a large extent, be attributed to the failure of many teachers to conduct the classroom demonstrations which should accompany the principles being studied.

It is true many demonstrations could be made with the material at hand, but many teachers lack the initiative or time or money to prepare them. Whether the cause for not

conducting these demonstrations is the lack of initiative or the lack of time or money, there is a need for anything which will aid the teacher in presenting her subject and give the student a clearer comprehension of that subject.

It is society's obligation to supply materials for effective teaching rather than to expect the teacher to gather at her own expense of time and money makeshift apparatus. As an agency of society, the school is of course obligated to society. The school is not only to perpetuate that society but to improve it. Society, moreover, owes to the school the means by which that improvement can result. The development of the scientific method as a way of thinking is advocated by progressively-minded educators everywhere. Presenting accurate observations and drawing conclusions is a concrete step in this development.

The need of all youth to understand the methods of science, the influence of science on human life, and the main scientific facts concerning the nature of the world and of man was one of the ten "imperative educational needs of youth"[1] which became the ground work of the curriculum in the American City secondary schools.

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[1] Educational Policies Commission, Education for All American Youth, pp. 226-270.

In order to meet this need, a basic course in science is a required part of the program for all students. A chief aim of this course is to help students understand the social significance of science.

Schools have in the past been principally concerned with a type of descriptive knowledge about the results of scientific development. The real concern should be directed to science as a way of thinking and a force which may or may not contribute to social good, depending upon control. To accept this point of view will mean that the science program will be concerned with the contribution of science in the:

1. Change in man's natural environment
2. Change in man's social environment
3. Change in man's intellectual life[2]

Improvement in the practice of relating science concepts to social consequences is becoming increasingly apparent. However, many science programs are developed in such a manner as to justify the following condemnation as made by Dewey.[3]

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[2] J. Murray Lee and Dorris May Lee, The Child and His Curriculum, p. 453.

[3] John Dewey, "The Challenge of Democracy to Education," Progressive Education, Vol. 14, February, 1937, pp. 82-83 as quoted by J. Murray Lee and Dorris May Lee, The Child and His Curriculum, p. 454.

> How far is science taught in relation to its social consequences, actual and possible, if the resources which science puts at human disposal were utilized for general democratic social welfare? I know that very great improvements are being made, but I am afraid that science is still taught very largely as a separate and isolated subject and that there are still those, including many scientists themselves, who would think that wonderful thing "pure" science would be contaminated if it were brought into connection with social practice. Yet without this connection, students are certainly getting very little intelligent understanding of the forces that are now making human society and that might remake it.

Science means many things to many different persons. To some it is typified primarily by the miracles of technology which have changed the face of civilization and which exert a continuing impact on all aspects of modern society. To others science signifies predominantly an intellectual enterprise marked principally by precision, so that it tends to fuse with mathematics; or by the ordering of evidence, so that it tends to fuse this regard with certain social sciences. To still others it represents primarily a body of knowledge and hypothesis concerning the material world.

Science partakes of all these things. But if it is to be considered fruitfully, and its contribution to general education evaluated, it must be defined more adequately. From our point of view, says the Harvard Committee, science is primarily a distinct type of intellectual enterprise, involving highly restricted aspects of reality and prepared as such to make particular types of contribution

to general education.[4]

It is the constant appeal to things as they are which makes the direct experience of field and laboratory essential in scientific education. Needless to say, this is only to the degree that work in the field or laboratory is designed not merely to keep students busy or to develop technical proficiency, but to provide directly the materials of scientific argument and the tests of scientific hypothesis. For this purpose no elaborateness is needed.[5]

Although there are now available kits for elementary science in the form of units, no "portable laboratory" within the financial reach of the average school has been offered. These kits contain units on air, water, magnets, weather, and several others, the entire number of units totaling eight. The prices range from $7.50 to $14.00 per unit. The demonstration desk would present greater opportunities, would furnish motivating power and develop further interests rather than exploit present interests *per se*. It is not intended that this portable laboratory supplant the regular laboratory, but that it substitute for it in schools that are unable to equip a regular laboratory.

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4. *General Education in a Free Society*, Harvard University Press, p. 150.

5. *Ibid*., p. 151.

Summary. The purpose of this project is the development of a portable laboratory for improving the teaching of science in a junior high school. Designing a demonstration desk and determining the types of appliances and the kinds of supplies to be used with the desk, are specifically entailed.

Science is ineffectively taught at the present. Suitable demonstration equipment could improve the teaching of science and develop the scientific method as a way of thinking.

Reality is a characteristic of functional science.

The science program should develop an understanding of the social significance of science.

Laboratory experience is imperative in scientific education. A "portable laboratory" could provide for this need in the schools that do not have a regular laboratory.

CHAPTER II

REVIEW OF LITERATURE

Science teaching is concerned with materials and method of operation. Much has been written regarding the science activities that operate within the school, and the various objectives of science have been emphasized. These are available in many writings, and their differences are due to the point of view of the composers and to the consequent desire for emphasis upon certain phases.

OBJECTIVES OF SCIENCE TEACHING

The Florida State Department of Education[1] explains that although it is advocated in Ways to Better Instruction in Florida Schools that each school form its own objectives in light of the adopted school philosophy, suggested purposes and functions are helpful. It is maintained that all science activities should provide learning experiences of progressively increasing complexities for enabling the learner:[2]

To develop skills in applications by working with common appliances;

To understand how generalizations are made and to enable him to form generalizations of his own;

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[1] A Guide to a Functional Program in the Secondary School, p. 410.

[2] Ibid., pp. 410-412.

To develop the ability and habit of observation;

To appreciate man's struggles to survive by applications;

To appreciate the value of work and to form an attitude against non-productive parasites (a mandate of nature is that all must live through their own efforts to secure the essentials for existence);

To appreciate the recreative possibilities in science activities;

To understand the impact that scientific applications have on social relations and day by day living;

To understand the historical and present effect of science in the realm of thinking;

To form attitudes (requiring special emphasis) on personal and community health practices and regulations; and

To develop the scientific attitude.

Generalizations to be stressed in the science program are:

The structure of all matter is probably electrical;

Man's method of living has been greatly altered by the applications of electricity and magnetism;

Energy is transformed for use by machines;

The earth's chief source of energy is the sun;

The physical status of matter is determined by the kinetic energy of molecules;

Energy as well as matter may be changed but can be neither created nor destroyed;

Physical as well as chemical change indicates energy change;

Only by an external force can the motion of an object be changed;

The amounts of substance produced by a chemical change are related in quantity to the amounts doing the reacting;

A limiting factor to life is light;

All life has developed from simpler forms of life;

Going on within each organism are processes vital to its existence;

Society, as well as structural forms of life, is greatly influenced by the physical environment;

Every substance is either an element, a compound, or a mixture;

There are fewer than a hundred chemical elements; and

Sound consists of waves set up in a ponderable medium by a body vibrating.

In _A Brief Guide to the Teaching of Science in the Secondary Schools_,[3] attention is directed to the importance

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[3] _A Brief Guide to the Teaching of Science in the Secondary Schools_, p. 7.

of the science teachers' knowing what they are trying to do. They should have reasons for their topics and their methods; they should understand what is desired in the development of young people who study science. In preparing individuals for understanding the social, economic, and political aspect of an age to be dominated by atomic energy, science will play a significant role.

Although detailed purposes and by-products of science teaching are numerous, broad objectives may be expressed in a few comprehensive principles. A Brief Guide to the Teaching of Science in the Secondary Schools presents the following aims:[4]

To illustrate the laws of nature, the principles and processes at work in the environment, thus implementing the maxim: "Knowledge is power."

To train in accurate, selective observation, and precise methods of arranging and interpreting data.

To show how data may be translated into maps, graphs, charts, and tables for clear interpretation.

To give practice in the expression of scientific ideas in clear and correct English speech and writing.

To give insight into the history of science as the background of its present significance.

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[4] Ibid., pp. 7-9.

To develop appreciation of the effects of science - past, present, and future - throughout the world.

To demonstrate the practical applications of science to community, home, and personal problems.

To increase the understanding of our Nation's need for conservation - the wise use of its resources and of science as the basis of its practice.

To substitute scientific methods of thinking for superstition and prejudice as bases of judgment in civic, economic, and social problems and in the development of character.

Since a student's life during the junior high school years is concerned largely in reacting and adjusting to physical and social environment, his science studies should be related to his life. The junior high school sciences are a link between elementary science which centers around familiar facts and the science of the senior high school which presents the foundations of special science areas. There should, therefore, be included among the objectives of junior high school science the following:[5]

To show how environment is related to the affairs of men in order that the pupil may more fully appreciate the services of science in the community.

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[5] Ibid., pp. 11-12.

To develop a variety of contacts and interests which will be helpful for vocational and avocational activities.

To help the pupil discover his needs, interests, and abilities in order to select his future science courses.

This bulletin includes a chart showing the scope and sequence of the elementary science program that the secondary science teacher may know the backgrounds of learning experiences in science. Leading the pupil to recall these earlier experiences will improve the learning situation. New concepts and understandings should be based upon the concepts developed in the elementary science program.[6]

TRENDS OF EDUCATION

For All American Youth. The Educational Policies Commission points out that the educational needs of all youth should be met.[7] Eight categories of educationally significant differences are illustrated. First there are differences in intelligence and aptitude which will exist regardless of modifications in the environments of individuals. These differences require different educational procedures, content,

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6. A Brief Guide to the Teaching of Science in the Secondary Schools, the chart following p. 42.

7. Educational Policies Commission, Education for All American Youth, pp. 15-19.

and standards of speed and achievement. Second, there are differences in occupational interests and outlooks. These differences require guidance and curriculum adjustments that provide the necessary preparation for thorough workmanship in all occupations. They require administrative arrangements that will remove or minimize undemocratic social distinctions among occupational fields. Then the differences in availability of educational facilities must be considered. These, the Commission contends, can be eliminated through administration and finance. Further, there are differences in the types of communities in which youth reside. These differences can be met through guidance programs providing information and outlooks which transcend community barriers and by curriculums adjusted to the needs and opportunities of diverse communities. Fifth, are the differences of opportunity resulting from differences in social and economic status and often aggravated by differences in race. These require wise educational leadership and administration. Then the differences in parental attitudes and cultural backgrounds are a significant consideration. Cultural differences can be utilized for valuable educational purposes, and a program of parent education can build desirable attitudes. Seventh, there are differences in personal and avocational interests which may be provided for through a broad curriculum. Finally, there are differences in mental health, emotional

stability, and physical well-being which must be met through appropriate adjustments in curriculum and regimen and by remedial health instruction and school health services.

The common qualities of youth are as significant to education as their differences. All American youth require education for civic responsibility and competence. All require an understanding of family relationships. All require an understanding of the main elements in American culture. All need to maintain their mental and physical health. All need occupational guidance and training and orientation to current economic conditions. All need to appreciate the significance of truth and to develop the capacity to think rationally. All need insight into ethical values. Specifically they need to grow in understanding the basic tenet of democracy, the surpassing worth of each individual.

What humanity will achieve in the next generation depends on youth and on their education now. Each of them is more precious than material goods or systems of philosophy. Not one of them is to be wasted. All of them are to be given equal opportunities.

The teachers of science have a particular responsibility in providing for both the differences and the common needs of youth. In fact, one of the common educational needs as given by the National Association of Secondary-School

Principals is understanding the influence of science on human life.[8] The scientific method of thinking, so essential to individual success and individual and collective welfare, is a specific objective of science. Furthermore, particularly stressed among the purposes of science teaching is producing responses in desirable behavior.

Since science at the junior high school level is especially concerned with everyday living, it can contribute significantly to the newer trends in secondary education. The Florida State Department of Education mentions five outstanding educational trends of the present.[9] The first of these, using the school to develop democratic living, will train for true democratic living only if there is actual experience in intelligent social action in which every student has a share. Relating the school to community resources and needs requires the projection of the school program into the life of the community, especially in the areas of health, home living, applied economics, and recreation. To provide a wide range of opportunities a school must give attention to the development of individuals, to vocational guidance, to

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8. Planning for American Youth, p. 10.

9. A Brief Guide to the Teaching of Science in the Secondary Schools, pp. 2-7.

instruction in family relations, to a health program, to recreational facilities, and to courses fundamental to democracy. Then broadening the program to meet the needs of youth groups requires a strong basic program of general education, a vital and varied program of special interests, and a cooperative program with participation of individuals and agencies in the community, county, state, and region. Finally, focusing the efforts of all teachers upon common goals is necessary for the realization of the goals implied in the first four trends. Subject-field specialists must learn to work together. No one teacher and no one division of a school may accept mere responsibility for an isolated area of a youth's education. Many matters must be adjusted to fit each other as the youth develops. Unrelatedness and isolation are psychological impossibilities in the learning process.

Science has particularly integrative possibilities. These possibilities are evident in the functions of science.

The Functions of Science. Functions are implied in the objectives of science teaching. However, there is a distinction. The Florida State Department of Education clearly distinguishes objective and function.[10] Between

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[10] A Guide to a Functional Program in the Secondary School, p. 44.

the goal and the attainment of the goal lies the work to be done, the performing, the doing, the functioning. What needs to be done to attain desired ends may be termed functions. The word "function" has come into the field of education because of the need for a realistic approach. For example, health is referred to as one of the major objectives of a school. A function of the school would be to provide the situations, experiences, knowledge, conditions necessary to secure the health of the pupils. Ideals are empty unless they function in the individual and the institution.

Lee and Lee[11] state that experiences are the means by which aims are attained. Only when these aims are continuously utilized as criteria for the selection and guidance of experience will their realization be possible.

No science teacher can escape social responsibility. Science activities operate within the school. Their purposes should be the purposes of schooling; the science phase of schooling should explain its operations within the purposes of the whole school program. Science is not a thing apart. Its findings require interpretation for human usage. They are of little value without it. Choosing experiences that

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[11] J. Murray Lee and Dorris May Lee, The Child and His Curriculum, p. 456.

will develop youth for participation in the American economy is a direct responsibility of all teachers. The science teacher must not shirk his equal responsibility. Progress should be determined by the important changes taking place in the learner, many of which are so gradual and imperceptible that they defy measurement or discovery by any known methods to date. Effective educational values are expressed by the interests, desires, understandings, attitudes, abilities, and habits that are developed within and by the learner. Behavior of the learner is the real test of the effectiveness of both the teaching method and the learnings from them. Evidence of progress has a stimulating effect upon pupils. They all react favorably to the feeling of successful action.[12] The Florida State Department of Education offers constructive means of stimulating effort toward attaining desired ends in a functional program. It is proposed that value be put in evaluation by giving recognition for[13]

1. Citizenship - attitude toward others, spirit of cooperation.
2. Participation in class and laboratory activities.
3. Contributions to school museum and laboratory materials.

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12. A Guide to a Functional Program in the Secondary School, pp. 378-410.

13. A Brief Guide to the Teaching of Science in the Secondary Schools, p. 29.

4. Cleanliness, orderliness, and efficiency in the laboratory.
5. Efforts toward excellence in drawings and diagrams.
6. Efficiency in one or more major projects.
7. Clarity and organization in reports on books, references, and current material, written and oral.
8. Achievement on quizzes, tests after units, and final examinations.

Although laboratory work is primarily to develop specific skills and to motivate learning, it is pointed out that laboratory experiences properly guided will result in habits of resourcefulness, responsibility, honesty, neatness, and respect for other people's property and for school property.[14]

The Harvard Committee alleges that among the most important values and basic ideas that science should contribute to general education are direct observation and precision.[15] Science is distinguished by a persistent effort toward precision. Science instruction in general education should be characterized mainly by broad integrative elements - the comparison of scientific with other modes of thought, the comparison and contrast of the individual sciences with one another, the relations of science with its own past and with general human history, and of science with problems of human society. These are areas in which science can make a lasting contribution to the general education of all students. Below the college

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[14] *Ibid*., p. 39.

[15] *General Education in a Free Society*, pp. 150-156.

level, virtually all science teaching should be devoted to general education. In the very young, science instruction primarily takes the form of conveying some familiarity with the world of immediate experience, and this necessarily proceeds mainly by direct contact and emphasis on fact and classifications. The integrative element is the student's own mode of life and his personal relation to the immediate environment. But as one leaves direct experience, and the immediate and familiar, an increasing need arises for an intellectual structure. As the facts of science and the experiences of the laboratory become further removed from the student's experience, when they no longer represent simple, spontaneous, and practical elements directly related to his daily life, these facts must be learned in another context - cultural, historical, and philosophical.

The Association for Childhood Education[16] declares that science has done more to stimulate the process of civilizing than any other social force. However, it is only recently that leaders in the scientific field have urged their colleagues to take the social responsibility that is theirs. Science experiences can give the child much satisfaction without including the social purposes that many con-

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[16] Herbert S. Zim, This is Science, pp. 30-34.

sider the core of science. They attain social value only when the teacher guides individual interest into group activity. Without a social purpose, scientists are reduced to that nineteenth century caricature - the absent minded professor so intent on his search for truth that he has forgotten the very reason for his searching.

Science experiences promote a type of total growth. The phases of growth - physical, intellectual, emotional, and social - are closely integrated. Satisfying social experiences add emotional maturity and _vice versa_. The young child soon understands that he must strive if he expects praise and reward and that he is expected to use his individual talents to secure a favorable place in the social group. The process of doing so might easily be termed the development of personality and in turn may be considered the sum total of the growth pattern of the individual. Any school experience that contributes to adjustment in social situations contributes directly to the development of the pupil's personality.

An essential aspect in social growth is the absorption of our customs and mores by the child, for which the school is solely responsible. The child draws on his entire environment for his ideas of honesty, right, good, and his concepts of persons and property. Yet the school can highlight certain phases of the process and point out by example and illustration our cultural ideals.

In the field of science there are stories dramatizing traits which Americans culturally prize: courage, determination, initiative, altruism, and modesty. There are rich and dramatic stories in the lives of the scientists - stories that contribute to the understanding of American ideals and aspirations in a neighborly world.

Dramatization and story telling about science are not to replace experiences and experiments. There is no substitute for the doing of science. Yet that doing can be greatly enriched by the proper introduction of stories and anecdotes about men who made science their life work.

Social growth comes from the experience of many varied situations. There result changes in attitudes and interests. These changes may be revealed in anecdotal records or in the individual's position in various subgroups that develop within the class. Science education is concerned with developing the mature individual, one who will not only benefit from scientific achievements but who will understand the facts and methods of science and who will therefore be in a better position to see that science is more and more widely used in a world which often has used it so unwisely.

ENRICHING THE TEACHING OF SCIENCE

Reference has been made to enriching science teaching through functional experience. The Florida State Depart-

ment of Education[17] points out ways in which the conventional textbook method of teaching science can be enriched. Professional magazines, authentic materials in newspapers and popular magazines, radio and screen programs provide interesting and up-to-date information. Although health may be taught as a separate course, the teacher of science is not relieved of a definite responsibility for teaching the principles of health in every appropriate lesson of their own field. Visual aids at the correct level of understanding should be used as freely as they are available. Such experiences as class field trips, visits to museums, self-initiated excursions, outside reading and experimentation, and collections provide interesting material for oral and written discussion. At the ninth grade level new habits of study must be employed, and new excellence in achievements must be required. Increased guidance with the beginning of vocational aspects should be given. The interests, attitudes, and peculiarities of each student should be focused to their fullest realization. Clubs help in developing a sense of security by giving the student added confidence in his own ability and making him feel that he is a member of the group. Engaging in such essential class activities as taking care of the stock rooms,

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17. A Brief Guide to the Teaching of Science in the Secondary Schools, pp. 19-24.

operating projectors, manipulating apparatus, keeping records, presenting reports and experiments are valuable means of developing desirable attitudes and abilities. Knowledge of achievements of scientists, of social and industrial procedures, devices for the economy of time and effort, insight into many occupations are definite needs. The ability to understand, appreciate, and apply this knowledge to everyday environment gives science a particular enrichment from a functional standpoint. Awakening interest in the fields of specialized science is a definite part of junior high science teaching. Teaching by demonstration and experiment is an important part of science which is specifically enriching. Demonstrations and experiments help answer certain problems. Laboratory work should accompany the classroom discussion of a problem or a principle. Demonstrating models and experiments that have been prepared outside of class should be encouraged. An outline of experiences for enriching the science course is given.

I. Excursions or school journeys:

  A. Conducted tours of: water plants, electric plants, communications offices, industrial plants, packing plants, mining enterprises.

  B. Making surveys of: health and safety, erosion and control, weather, climate, soil (soil profile), local plants and animals.

  C. Making studies of: truck farming, groves (citrus, pecan, tropical fruit, and tung oil), nursery, naval stores, timber, sponges, fish, cattle raising.

II. Class activities:

- A. Collections (often outgrowth of school journeys): rocks, shells, fossils, minerals, Indian relics, insects, flowers, leaves, wood sections, seeds, specimens to preserve.
- B. Models (mechanical): airplanes, boats, locomotives, coaches, telephone, telegraph, radio, wiring in series and parallel, generators, electric motors, electromagnet, electric bells, wiring model houses, wet cell batteries, simple machines.

III. Designed materials:

- A. Cartoons (to bring out principles of science).
- B. Maps (weather, polar, magnetic, pictorial, sky, products).
- C. Globes for sky and earth study.
- D. Charts: commercial and home made.

IV. Use of audio-visual aids:

V. Supplementary reading:

- A. Library of science materials on different grade levels.
- B. Current readings in science.

As has been implied science is enriched through making other subjects functional. For instance, giving practice in the expression of scientific ideas in clear and correct English speech and writing, providing experiences for oral and written discussion, keeping records of demonstrations and experiments make English functional.[18] Art

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[18] A Brief Guide to the Teaching of Science in the Secondary Schools, pp. 7 and 20-23.

activities inspired by science enhance and enrich.[19] Illustrations improve reports. Other drawings may be included in laboratory sketches and diagrams, charts and posters, maps, and lantern slides. Such art activities as making models using soap, clay, papier-mache, plaster of Paris, and other media; preparing photographic, ink, spatter, block, and blue prints; constructing notebook covers and organized scrapbooks; improving the appearance of the room with artistic flower arrangements, attractive bulletin boards and displays furnish pleasure and profit. Science offers a particular opportunity for functional mathematics. Students should be led to see a need for solving scientific problems, and as far as possible problems should be practical and within the realm of their interests.[20] Skill should be improved by review and reteaching. Further, science furnishes opportunity for democratic living.[21] Laboratory experiences properly guided result in habits of resourcefulness, responsibility, honesty, neatness, and respect for property. Working together aids in developing a spirit of cooperation and responsibility, an

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[19] Ibid., pp. 20 and 34-35.

[20] Ibid., pp. 59-60.

[21] Ibid., pp. 3, 29, 39 and 75-76.

attitude for furthering the general welfare of the group, and an understanding of the personal worth and dignity of every individual. A club gives opportunity for growth in social graces.

Craig[22] offers suggestions for enriching the science program through knowing and using community resources. The community is best understood in terms of the fundamental natural and social forces which have operated to make it what it is. The teacher should develop an understanding of the problems of a community in terms of the fundamental principles which are operating to create the problems as well as those which could operate to correct undesirable situations. The success of humanity depends upon application of scientific content and method to social problems.

The community is a laboratory. No area is devoid of natural resources. The welfare of mankind rests as much on his ability to utilize the resources wisely as on the resources themselves. The greatest resource in a community may be the soil. We shall never permanently succeed as an agricultural nation until our soil is managed by those who have a real interest in it. The nature of the soil determines health. When the relationship between soil and health is

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[22] Gerald S. Craig, Science in Childhood Education, pp. 55-86.

studied carefully, it may have much to do with the improvement of the health of the human race. Living conditions can be improved through land planning. Through education of the generation now in our schools, land planning can come as a result of democratic processes. Other community resources may include forest lands, water, wild life, mineral deposits, industrial developments.

It is important in a democracy that boys and girls develop a clear idea of some of the ways in which the resources can be used to the welfare of mankind. Many of society's ills can be remedied through science. Man, in securing for himself the best he can from the universe, must work with the natural forces of the earth. It is the clearly defined task of the science teacher to reveal to children the possibilities for an improved area. The great test of democracy will be determined finally not so much in terms of its armed strength as its ability to make adjustment to the impacts of science.

Summary. Since there are many differing points of view, various objectives of science receive emphasis. Although many educators advocate that each school form its own objectives in light of the school's philosophy, the Florida State Department of Education contends that suggested purposes and functions are helpful.

It is tremendously important that science teachers understand what is desired in the development of young people who study science. During the junior high school years science should be related to the student's life.

In seeking to meet the needs of all youth, science has a special place in the scheme of education. The teacher of science has a particular obligation in the cooperative effort of teachers and administrators in provision for differences. And a common educational need is the influence of science on human life.

Science has definite contributions to make to democratic living, community life, family relations, vocational guidance, health, and recreation.

Aims are attained through experiences. Functions are work that is done in realizing objectives. These functional experiences enrich science teaching.

Science makes other subjects functional also. English, mathematics, art, civic responsibilities become immediate needs in a socialized atmosphere.

Social responsibility is a recent realization of leaders in the scientific field.

Utilizing community resources enriches the science program and develops ability in making adjustment to the impacts of science. The great test of democracy will be determined by this ability.

CHAPTER III

THE PORTABLE LABORATORY

This is the name given for the complete unit which will be contained in a special demonstration desk mounted on rubber-treaded casters so that it can be moved readily from one room to another. See Figure 1.

THE DEMONSTRATION DESK

The Function. A well designed and equipped demonstration desk can improve the quality of any science teaching by making possible more effective lecture-demonstrations. During lecture demonstrations the desk is the focal center of pupil interest. Such interest is stimulated and held if the desk provides a clear view for each pupil. In addition to unobstructed vision, ample working area is important. The teacher's task is easier when the desk top is large enough to hold all necessary demonstration apparatus without crowding. Ready-to-use service equipment, built into the desk, helps to speed up demonstrations by cutting down the delays and the consequent loss of thought continuity.

These factors were carefully considered in designing the desk and selecting the proper equipment to accompany it.

The Construction. The top, as designed, is to be constructed of three quarter inch plywood and is covered with

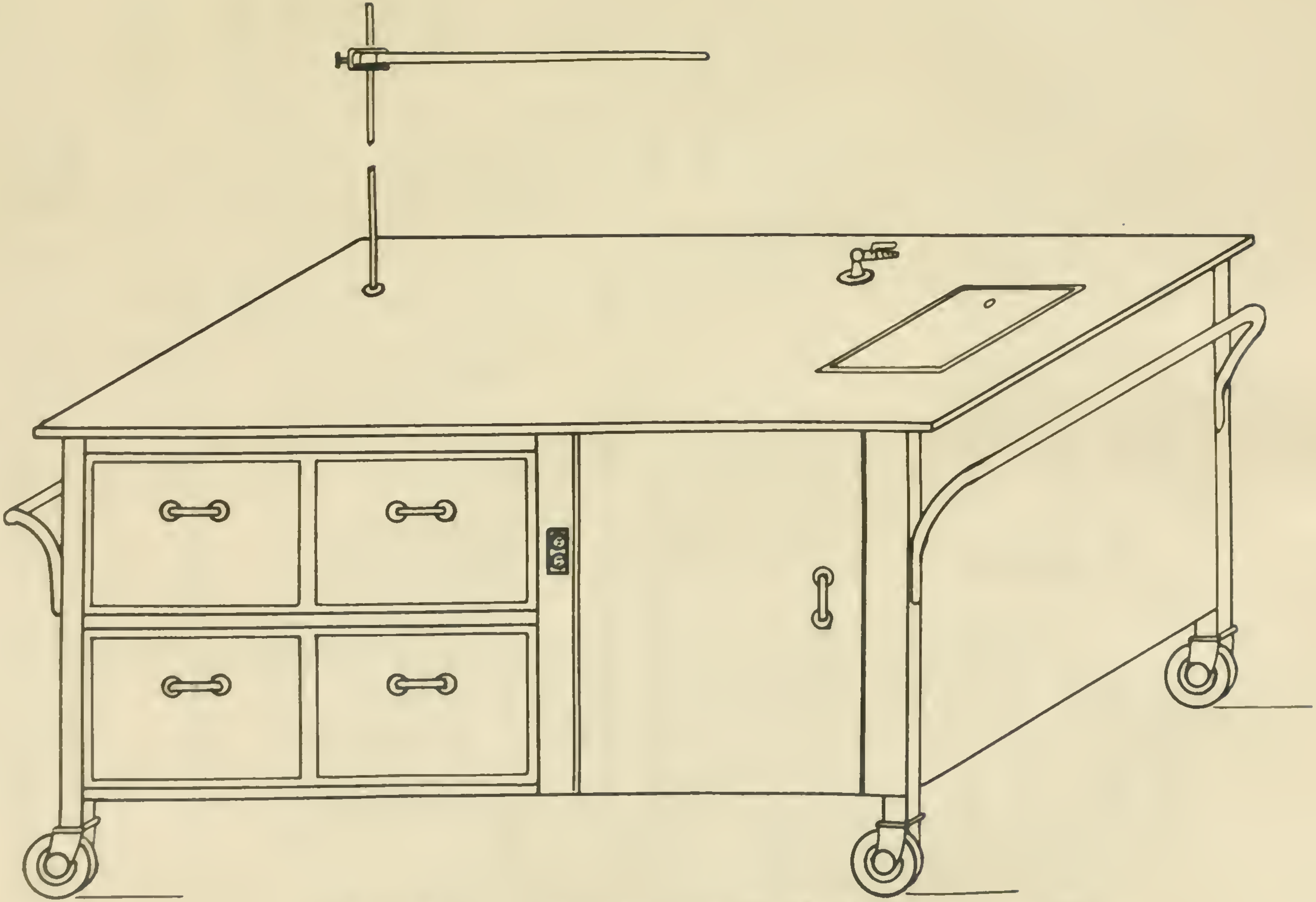

FIGURE 1 - PICTORIAL DRAWING OF DEMONSTRATION DESK

black laboratory enamel, see Figure 2. The working area is seventy-two inches by thirty inches which is large enough so that a group of pupils can gather around the desk for "close-ups" of demonstration experiments. Extra working space is afforded by a cover provided for the sink when it is not in use.

The frame is to be made of angle iron with welded joints. This welded steel construction provides for both lightness and strength. Figures 3 and 4 show how the frame is constructed. The top is fastened to the frame with screws inserted from the under side of the metal frame to the plywood top in order that there will be no metal on the top of the desk.

In addition to the space needed for four removable cases, a cabinet is incorporated in the desk with double doors on both sides, see Figure 1. The desk can be used with either side as "front side." This cabinet will provide ample space for installation of the service equipment and supplies when needed.

The bill of material for the desk, exclusive of the cases, is given on page 37.

Cases. It would not be practical to attempt to design in detail the cases which are to be incorporated in the demonstration desk without first having the material

Material 3/4" Plywood

Scale 1½" = 1' 0"

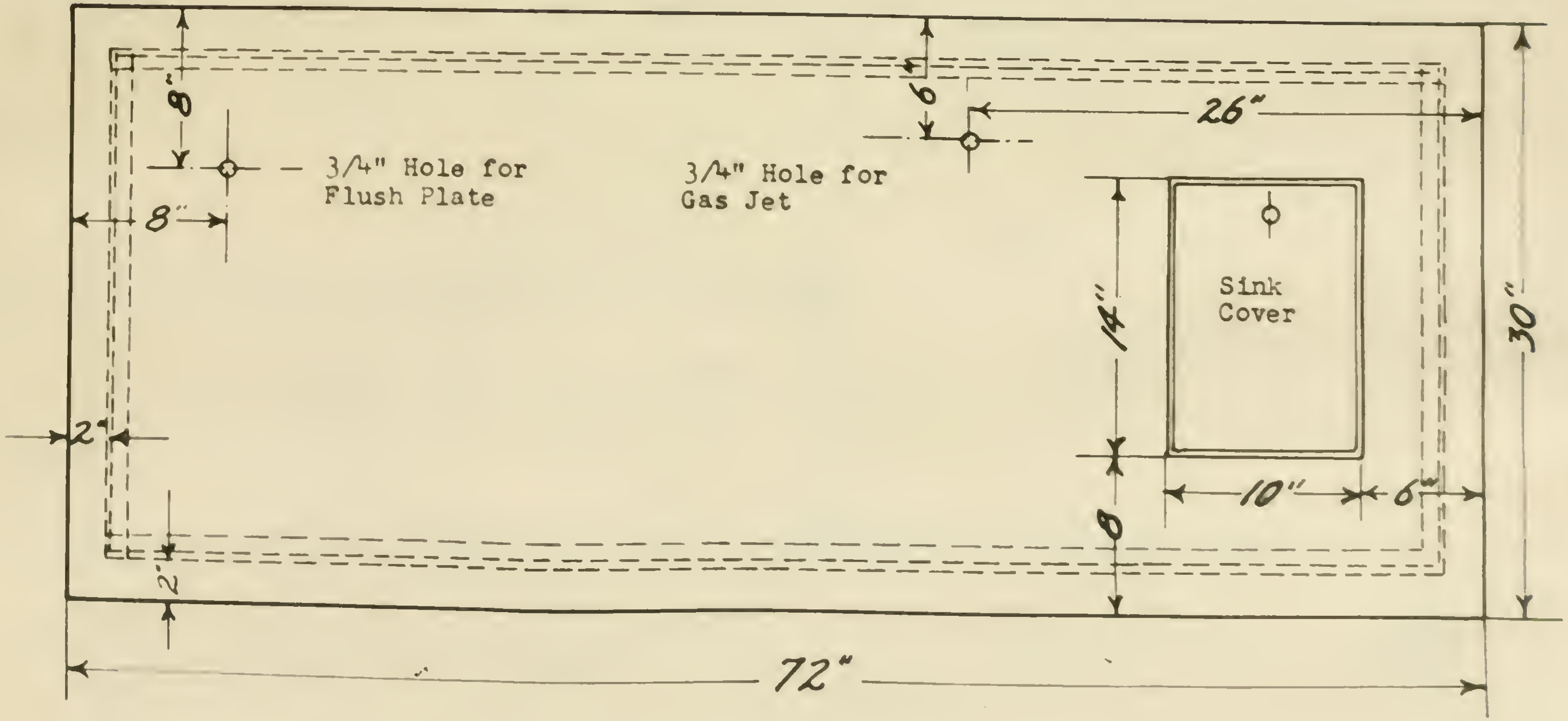

FIGURE 2 - TOP VIEW OF DEMONSTRATION DESK

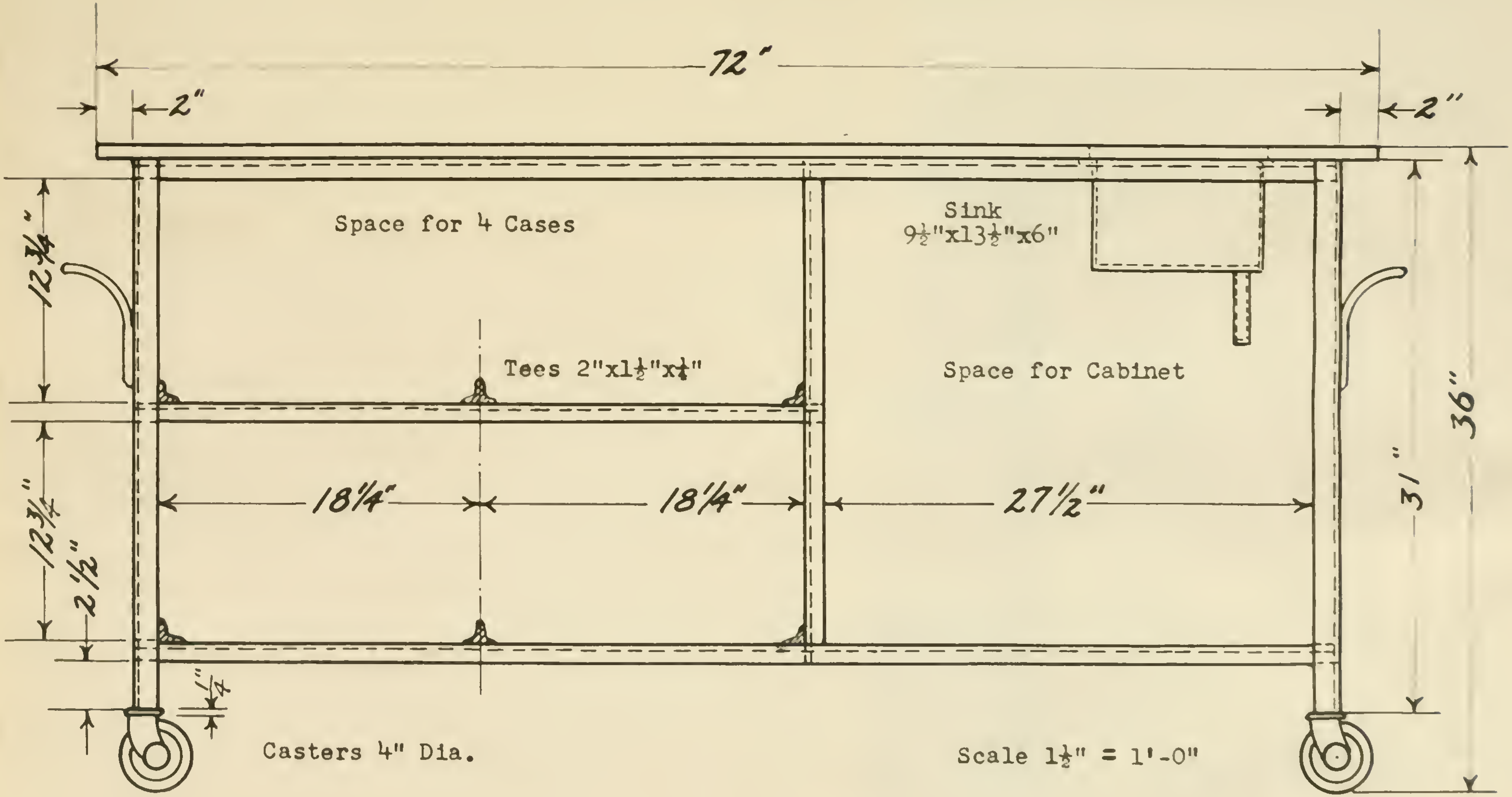

FIGURE 3 - FRONT VIEW OF DEMONSTRATION DESK

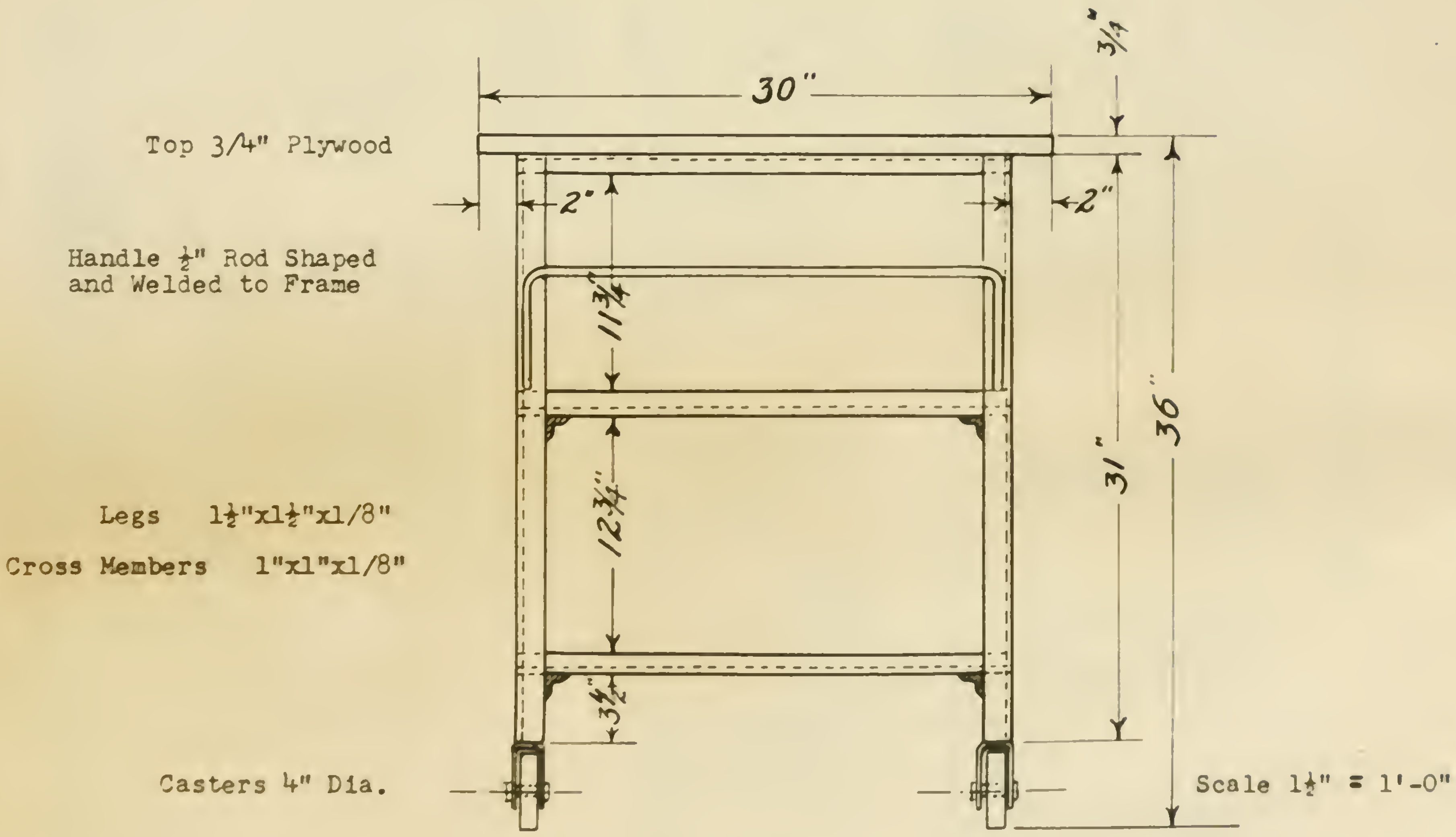

FIGURE 4 - END VIEW OF DEMONSTRATION DESK

BILL OF MATERIAL FOR DESK
(Exclusive of Cases)

Frame

Quantity	Material	Length of Each Piece	Total Length Required	Total Weight
4	L 1½"x1½"x1/8"	31"	10' 4"	12.7 lbs.
4	L 1"x1"x1/8"	68"	22' 8"	18.1 lbs.
2	L 1"x1"x1/8"	39"	6' 6"	5.2 lbs.
2	L 1"x1"x1/8"	28½"	4' 9"	3.8 lbs.
2	Tees 2"x1½"x¼"	26"	4' 4"	13.0 lbs.
2	Rods ½" Dia.	48"	8' 0"	5.3 lbs.
Total weight of material for frame				58.1 lbs.
Cost of material and fabrication				25¢ per lb.
Total cost of frame				$14.53

Woodwork

Quantity	Material	Size Each Piece	Total Sq. Ft. Required	Est. Weight	Cost
1	3/4" Plywood	72"x30"	15	26 lbs.	$7.50
2	5/8" Plywood	24"x28½"	10	14 lbs.	5.00
1	5/8" Plywood	30"x26"	13	18 lbs.	5.20
2	1/4" Plywood	26"x28½"	10	5 lbs.	2.50
4	3/4"x4" Strips	28½" long		4 lbs.	1.00
Total				67 lbs.	$21.20

Miscellaneous

Quantity	Material	Cost
1	Galvanized sink 9½"x13½"x6"	$ 5.00
1	Gas jet	4.00
1	Support arm	3.00
1 qt.	Varnish	1.50
1 qt.	Laboratory enamel	1.95
3 doz.	3/4" screws	.20
2 doz.	1/2" stove bolts	.15
2 doz.	7/8" stove bolts	.15
4	Hinges	.30
2	Locks	1.00
4	4" casters	3.00
1	Gas tank with fittings	30.00
1	Transformer	2.00
Total		$52.25

Estimated cost of labor in assembling desk	$10.00
Total estimated cost of desk	$98.00
Total estimated weight of desk	130 lbs.

at hand which is to be stored in them. Compartments should be provided for the apparatus and arranged in such a manner that the contents are easily accessible. Therefore the plans as given here (Figures 5, 6, and 7) show only the necessary outside dimensions and the arrangement for opening. The material specified is three quarter inch plywood throughout, but in actual construction it may be found practical to use thinner plywood for the top and the side which opens. The case must be constructed sturdily, but by incorporating compartments, extra strength will be provided which perhaps would warrant lighter materials as suggested.

The bill of material (page 42) is necessary for the construction of the four cases without the compartments. However, the estimates shown for the weights and costs of labor to build the cases takes into consideration the compartments.

The cases are to be made so that they will fit into the space provided for them in the desk, see Figure 1. When the laboratory is in use, the cases can be removed from the desk and set on a table or desk where their contents are readily accessible.

The Service Equipment Provided. One of the outstanding features of the desk is the provision of gas which makes the use of a Bunsen burner possible. There is no doubt that the Bunsen burner is the most used and most

Scale 2" = 1'-0"

Material 3/4" Plywood

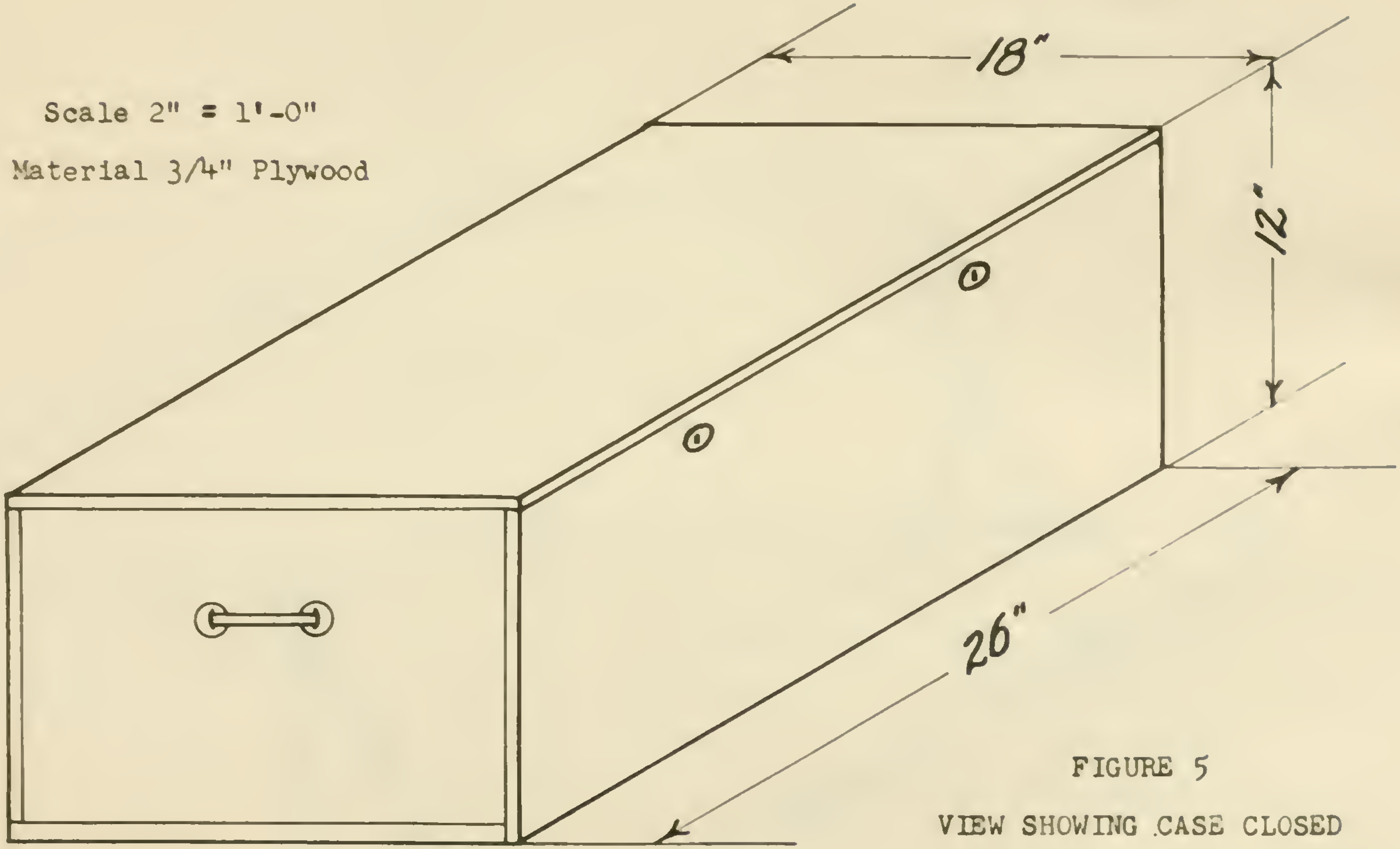

FIGURE 5

VIEW SHOWING CASE CLOSED

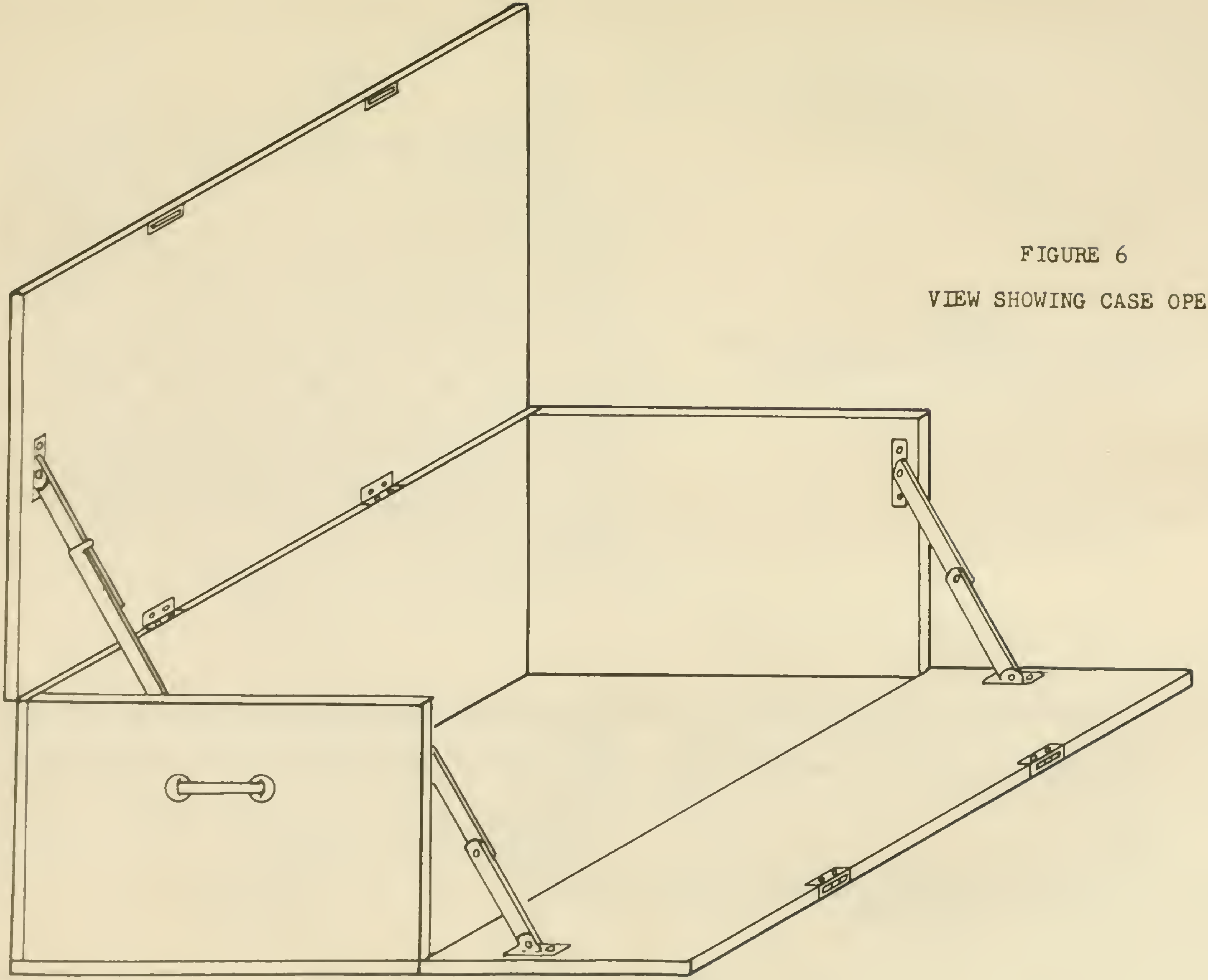

FIGURE 6

VIEW SHOWING CASE OPEN

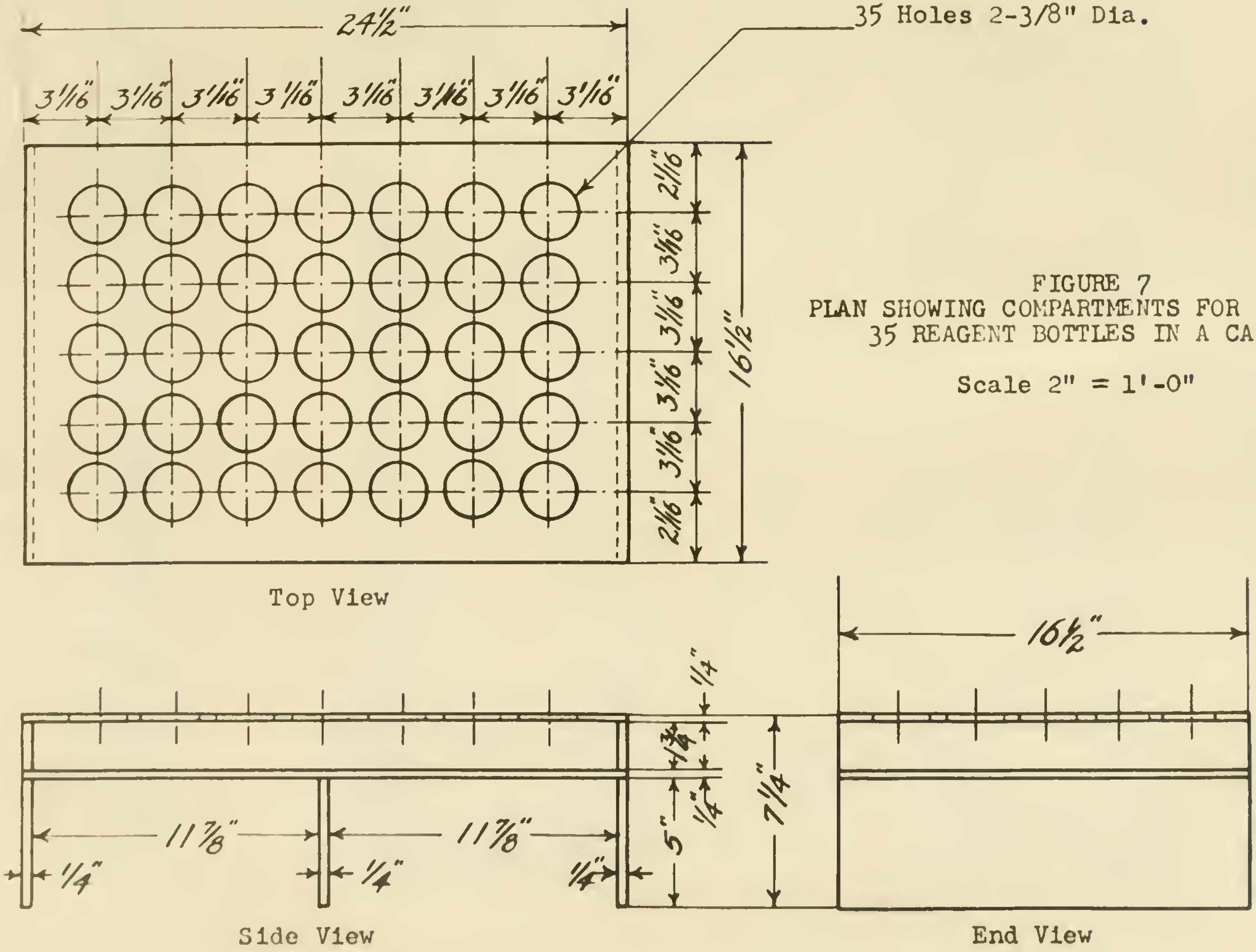

FIGURE 7
PLAN SHOWING COMPARTMENTS FOR STORING
35 REAGENT BOTTLES IN A CASE

Scale 2" = 1'-0"

BILL OF MATERIAL FOR FOUR CASES
(Less Compartments)

Plywood

	Quantity	Dimensions of each piece	Total Sq. Ft.
Top	4	18"x26"	13.0
Bottom	4	17¼"x26"	12.4
Ends	8	10½"x16½"	9.6
Fixed Sides	4	10½"x26"	7.5
Open Sides	4	11¼"x26"	8.1
Total Square Feet			50.6
Cost of Plywood			$20.00

Hardware

Quantity	Material	Cost
12	Stay and support hinges	$1.50
16	Hinges	1.20
8	Handles	1.00
8	Locks	4.00
8 doz.	1½" No. 8 screws	.40
12 doz.	½" No. 3 screws	.50
1 lb.	Glue	.50
1 qt.	Varnish	1.50
Total cost of hardware		$10.60

Estimated labor to build four cases with compartments	$30.00
Estimated weight of each case with compartments	20 lbs.
Total estimated weight of four cases with compartments	80 lbs.
Total estimated cost of four cases with compartments	$65.00

necessary piece of apparatus in a laboratory.

The following items are permanently incorporated in the desk ready for immediate use which enables the teacher to perform efficient and interesting demonstrations: gas tank with fittings and jet, sink, support arm, and 110-6 volt transformer.

RECOMMENDED APPLIANCES AND SUPPLIES

The selection of the apparatus and supplies to be incorporated in the laboratory was largely determined from the Florida State Adopted Science Textbooks used in the seventh, eighth, and ninth grades, both the old and the new series.[1] All the materials needed to conduct the recommended experiments and demonstrations are tabulated and organized in separate groups as follows:

List 1 - Laboratory Chemicals. List 1 (page 46) groups all the chemicals together. It is desirable to put the chemicals in bottles of a uniform size in order to conveniently arrange them in a minimum of space in the case.

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[1] Samuel Ralph Powers, et al, Exploring Our World.
Samuel Ralph Powers, et al, Our World Changes.
Franklin B. Carroll, Frank A. Rexford, and Henry T. Weed, Understanding the Universe, Book Three.
Victor C. Smith and Gilbert H. Trafton, Exploring Science.
Victor C. Smith and Gilbert H. Trafton, Enjoying Science.
Victor C. Smith and Gilbert H. Trafton, Using Science.

Liquids should be put in a four-ounce narrow mouth type of reagent bottles and crystals in the four-ounce wide mouth type.

One case from the demonstration desk is designated for the storage of chemicals only. A suggested plan for the necessary compartments for storing chemicals in the case is shown in Figure 7. In the top section there are spaces for thirty-five standard four-ounce reagent bottles in which the liquid and crystal chemicals are placed. The lower two compartments may be utilized for storing the larger solid chemicals and miscellaneous supplies.

List 2 - Laboratory Accessories. The materials contained in this list (page 47) are the laboratory appliances necessary in conjunction with the chemicals for conducting the experiments and demonstrations. These appliances should be arranged in a separate case in suitable compartments so that they will be readily accessible.

List 3 - Demonstration Apparatus. The items in this group (page 48) are essential for many of the special demonstrations in various fields of physics. Most of these items as furnished by manufacturers and distributors are in special cases or boxes in which they should be kept when not in use and stored in the designated case for such equipment. However, the larger pieces such as the microscope and the triple beam

balance should be kept in the cabinet section of the demonstration desk.

List 4 - Miscellaneous Equipment and Supplies. The materials shown in the previous lists are of a special nature and usually must be obtained from a laboratory supply house. The miscellaneous supplies given in List 4 (page 49) are commonplace but necessary items which can be obtained easily locally.

One of the four cases should be assigned for the storage of all miscellaneous material. Items such as starch, salt, and washing soda should be put in the chemical case. The galvanized pail is to be placed in the cabinet under the sink to catch the waste water. The purpose of the stone jar is for the disposal of the used chemicals.

List 5 - Desirable Equipment. The apparatus and supplies as shown on the preceding lists are considered adequate for conducting the essential experiments and demonstrations in connection with the teaching of science. However, there is other equipment which, if the school's budget would warrant it, would be desirable for introducing other fundamental scientific concepts and for opening new avenues of interest. List 5 (page 50) shows some of this desirable apparatus as well as the equipment necessary for conducting some of the experiments recommended in the textbooks although it has been intentionally omitted for the purpose of economy.

LIST 1

Laboratory Chemicals

Quantity	Description	Cost
1 qt.	Alcohol, Ethyl, denatured	$ .85
4 oz. bottle	Ammonium Chloride	.40
1 lb. bottle	Ammonium Sulphate, white pure	.30
1 4 oz. bottle	Boric Acid, C.P. Crystals	.30
1 lb.	Calcium Carbonate	.35
1 lb. bottle	Carbon Tetrochloride, C.P.	.40
1 lb. bottle	Charcoal, Animal	.50
1 lb. bottle	Chlorine Water	.45
1 oz. bottle	Cobalt Chloride, C.P. Crystals	.50
4 oz.	Copper Metal (.01 thick)	.35
1 oz. bottle	Copper Oxide, wire form C.P.	.40
1 lb. bottle	Copper Sulphate, Crystals, C.P.	.35
4 oz. bottle	Ether, Ethyl pure	.35
4 oz. bottle	Fehling's Solution Tablets, Solution A	.25
4 oz. bottle	Fehling's Solution Tablets, Solution B	.30
1 lb. bottle	Glucose, pure	.20
4 oz. bottle	Hydrogen Peroxide, 3% U.S.P.	.25
1 lb. bottle	Hydrochloric Acid, concentrated C.P.	.80
1 oz. bottle	Iodine Tincture, U.S.P.	.25
4 oz. bottle	Lead Oxide, yellow	.50
1 lb.	Lead, sheet, 1/32"	.50
100 bottle	Limewater Tablets	.40
1 vial	Litmus Paper, red	.10
1 vial	Litmus Paper, blue	.10
1 oz. roll	Magnesium ribbon	.60
1 lb. bottle	Manganese Dioxide	.30
1 lb. bottle	Marble Chips	.25
1 lb. bottle	Mercury Metal, virgin	4.50
1 oz. bottle	Mercuric Oxide, pure red	.60
1 lb. bottle	Nitric Acid, concentrated C.P.	.95
4 oz. bottle	Phenolphthalein Solution	.35
1 oz. can	Phosphorus, red amorphus	.40
4 oz. bottle	Potassium Chlorate	.50
1 lb. bottle	Potassium Hydroxide	.35
4 oz. bottle	Potassium Permangonate, U.S.P.	.30
4 oz. bottle	Sodium Peroxide	.40
1 lb. bottle	Sulphur Roll	.30
1 lb. bottle	Sulphuric Acid, concentrated C.P.	.80
1 lb.	Zinc Metal, sheet	.60
Total		$20.35

LIST 2

Laboratory Accessories

Quantity	Description	Cost
6	Asbestos Squares, 6"x6"	$ .17
1	Barometer Tube, with mercury holder and pipette	1.25
2	Beakers, 100 cc	.44
2	Beakers, 250 cc	.40
2	Beakers, 400 cc	.50
1	Blow Pipe, 8"	.45
6	Bottles, wide mouth	.35
3	Clamp, pinch	.42
1	Clamp for support	1.50
2	Clamp, test tube	.24
1 pkg.	Corks, assorted Nos. 0-11	.95
8	Cover Plates, 5"x5"	.48
1	Cylinder, graduated, 250 ml	2.00
1	Deflagrating Spoon	.17
1	Evaporating Dish, #3, 175 cc	.65
2	Files, triangular	.30
1 pkg.	Filter Paper	.25
4	Flasks, Erlenmeyer, 500 cc	1.40
1	Forceps	.30
1	Funnel, 75 mm 60°	.48
6	Glass Rod, 6"x3/16"	.23
1 lb.	Glass Tubing, 6 mm dia.	.60
1	Graduate, short form	.75
6	Medicine Droppers	.20
1	Mortar and Pestle, No. 0	.56
2	Petri Dish, 100x15 mm	.42
1	Pneumatic Trough, 4"x7"x10"	1.00
1	Pump, air	1.00
1 lb.	Rubber Stoppers, assorted	1.50
10 ft.	Rubber Tubing, 5/16"	2.00
1	Spatula	.17
1	Support with 3 rings, 3"x4"x5"	3.25
24	Test Tubes, 5"x5/8"	.66
1	Test Tube Holder for 13 tubes	.85
3	Test Tube Brush	.24
1	Thistle Tube, 30 cm	.65
1	Tripod	.95
1	Wash Bottle	.55
10	Watch Glass, 3"	.60
Total		$28.88

LIST 3

Demonstration Apparatus

Quantity	Description	Cost
2	Balance, spring	$3.00
1	Balance, triple beam	18.00
1	Bunsen Burner	.80
1	Ball and Ring for Expansion	1.75
2	Battery Jar, 2 quart	1.80
1	Buzzer	.60
1 set	Capillary Tubes	.75
1	Car for incline plane and pulley	3.05
1 set	Center of Gravity Cords	.65
1	Compass	.75
1	Compound Bar	.70
1	Conductometer, 4 metals	.70
1 set	Constant Level Tubes	2.75
1	Demonstration Balance	.80
1	Door Bell	.75
3	Dry Cells	1.50
1	Electric Hot Plate	3.00
1	Glass Rod and Silk	1.25
1	Gyroscope	1.50
1	Hard Rubber Rod and Fur	1.60
1 can	Iron Filings	.35
1 set	Lenses, set of six	2.50
1	Light and Socket, miniature	.35
1	Lodestone	.30
2	Magnet, bar	1.20
2	Magnet, horseshoe	1.50
1	Magnifying Glass	1.15
1	Meter Stick	.70
1	Microscope	20.00 and up
1	Motor, electric	2.50
1 set	Pulleys, set of 3, single, double, triple	1.60
6	Pith Balls with Silk Thread	.60
1	Prism	.85
1	Pump Model, force	1.85
1	Pump Model, lift	1.85
1	Pump Holder for above pumps	1.65
1	Push Button	.15
12	Rubber Balloons	.65
1 sq.ft.	Rubber Dam	.30
1	Switch, knife	.20
2	Thermometer, Centigrade	2.50
2	Thermometer, Fahrenheit	2.90
1	Tuning Fork	1.00
1 bundle	Wood Splints	.75
Total		$93.10

LIST 4

Miscellaneous Equipment and Supplies
(Can be procured locally)

Quantity	Description	Cost
1 sheet	Blotting Paper	$ .10
12	Bags, paper, assorted sizes	.10
5 yards	Cheese Cloth	.80
1 carton	Cotton, absorbent	.15
1 lb.	Epson Salts	.10
1 roll	Friction Tape	.10
1	Glass Tray, Approx. 8"x12"	1.00
1	Hammer	1.00
1	Ice Pick	.10
2	Lamp Chimney	.20
1 can	Lye (Sodium Hydroxide)	.10
1 yard	Muslin	.50
1 lb.	Nails, assorted	.15
1 lb.	Paraffin	.10
1	Pliers, combination	1.00
1	Protractor	.25
1 bundle	Rubber Bands	.05
1 box	Salt (Sodium Chloride)	.10
1 pair	Scissors	1.00
1	Screw Driver	.50
1 box	Soda (Sodium Bicarbonate)	.10
1 box	Staples	.05
1 box	Starch	.10
1 pkg.	Steel Wool	.15
1	Stone Jar, 3 gallons	1.00
1 ball	String	.10
1 pair	Tin Snips	1.00
1 box	Washing Soda (Sodium Carbonate)	.15
1 spool	Wire, copper #36	.30
1 spool	Wire, iron	.20
1 pt.	Vinegar	.10
1	Galvanized Pail, 16 quart	.50
1 gal.	Water, distilled	.10
Total		$11.25

LIST 5

Desirable Equipment (Optional)

Quantity	Description	Cost
1	Ammeter	$12.50 up
1	Aneroid Barometer	7.50 up
1	Aquarium	7.55 up
1	Dissecting Set	1.75
1 set	Fertilizer Samples	4.50
1	Galvanometer	20.00 up
1	Globe	15.00
1	Hydrometer	2.75
1 set	Microscopic Slides, prepared	7.50 up
1	Pump, vacuum and Pressure with Plate and Jar	20.00 up
1	Rock and Mineral Collection	7.00
1	Soil Testing Outfit	6.50 up
1	Telephone Receiver	3.00
1	Telephone Transmitter	2.50
1	Voltmeter	12.50 up
Total		$130.55

The thing most useful to the science teacher is proficiency in arousing the interests of pupils. The broadened curriculum emphasizes doing and working with things rather than merely studying books. This is doubly important in science. This designed laboratory does not solve all difficulties, but it is a step forward in providing equipment for demonstration and experiment, thereby arousing interest and improving instruction. Making actual applications of scientific knowledge is a primary purpose of science activities within general education. The learning situation is enhanced through demonstration and experimentation.

Some books offer suggestions for experiment that parallel advertisements on how to become a magician. They offer lists of trick methods without explaining the principles involved. However, the Florida State Adopted Texts contain many good experiments, but some laboratory equipment is necessary. Schools of limited means could make this possible by constructing a portable laboratory.

Summary. The portable laboratory is what its name designates. Service equipment and supplies are a part of it. Ample working space is provided for on top of the desk. All of the necessary equipment is included, not forgetting provision of gas, making the use of a Bunsen burner possible.

Both the top of the desk and the cases are constructed of plywood. The top of the desk is covered with

black laboratory enamel. The frame is constructed of welded steel.

The estimated cost of the desk itself is $98.00; the cost of the cases, with compartments, is $65.00.

The lists of recommended appliances and supplies, determined largely from the Florida State Adopted Science Textbooks, include laboratory chemicals (List 1), laboratory accessories (List 2), demonstration equipment (List 3), miscellaneous equipment and supplies (List 4), and desirable equipment (List 5). The combined cost of these supplies, exclusive of List 5, is $153.48.

The estimated cost of the entire laboratory amounts to $320.00. Demonstration and experiment are imperative for enhancing learning, stimulating thought, revealing truth, developing scientific thinking. It is possible for any school to construct a portable laboratory. The above figures include approximately $50.00 for labor. This amount could be saved if the school constructed the portable laboratory.

CHAPTER IV

TECHNIQUES IN USING THE LABORATORY

The responsibility for the operation and care of the portable laboratory should be delegated to one person, preferably to the science teacher who has a vital interest in teaching science.

It must be realized that the success of the portable laboratory rests entirely on how efficiently it is put to use, upon how effectively the apparatus is distributed for use by the various science classes. This will entail many important duties and will require the cooperation of every science teacher in the school if the program is to be successful. Some of these duties are:

1. Keeping an inventory of all supplies and replacing depleted items. A card index should be prepared. A separate card (3"x5") should be used for each item and all pertinent information regarding the article entered. This information should include:

Name of article
Serial number (if any)
Source of supply
Cost
Quantity on hand at this date
Place where stored (case number or cabinet)

The cards should be arranged alphabetically, placed in a suitable file box, and retained by the teacher in charge of the portable laboratory.

2. Maintaining and repairing the equipment. These are important duties for operating on an efficient and economical basis. Each piece of equipment should be carefully cleaned after using and any necessary repairs made before returning it to its specified storage place. Breakage of glass and porcelain wares must be taken into consideration. All broken pieces must be replaced, and it would be advisable to have a reasonable reserve of common items, such as test tubes and beakers. Any breakage should be reported immediately to the teacher in charge who should make the proper entry in her inventory and replace the items if the number on hand is low.

3. Preparing for laboratory and demonstration experiments. This will require careful planning on the part of all the teachers concerned in order to avoid any conflicts in their requirements for using the same equipment. Students can and should be trained to help with the routine tasks such as distributing and taking proper care of the equipment; however, the teacher must supervise the work and assume final responsibility for the favorable outcomes and for the safety of the students. Bulletin No. 8 of the Florida State Department of Education[1] sets forth eight safety rules for conduct in a laboratory. The students should become familiar with

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[1] A Brief Guide to the Teaching of Science in the Secondary Schools, p. 41.

these rules which may have frequent application in their everyday lives.

1. Properly label all containers. Before using read all labels carefully.

2. Never return unused chemicals to the original containers.

3. Use minimum quantities of materials.

4. Develop proper methods of testing by taste and smell.

5. Teach correct technique of handling bottle stoppers; of inserting glass tubing in stoppers.

6. Arrange for proper disposal of waste material, residues, and broken glass.

7. Explain fire control. Have material such as sand, water, or commercial extinguishers freely at hand.

8. Have students know the location and use of first aid supplies.

The Portable Laboratory in Operation. The following is illustrative of a suggested method. Miss A, Miss B, and Mr. C are science teachers in the seventh, eighth, and ninth grades. Miss B is in charge of the portable laboratory. The three teachers are in Miss B's room discussing the demonstrations they wish to make on the following day. Miss A wants to conduct a demonstration of "Can Air Be Measured"[2] and presents a list of equipment needed, as follows: rubber

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[2] Victor C. Smith and Gilbert H. Trafton, _Exploring Science_, p. 71.

balloon, glass tubing about six inches long and curved slightly at one end, rubber band, glass measuring cup, and battery jar. Miss B refers to the equipment file which she keeps on her desk and finds that all materials are on hand except the glass measuring cup; however, the inventory card shows that a short form graduate is available and this can be satisfactorily substituted. Miss B then notes beside each item on Miss A's list the number of the case or cabinet in which the article is stored.

Miss B wishes to demonstrate to her class "How Some Air Compressors Work."[3] In making out her list for the following equipment she indicates the storage case number beside each item: air pump, Erlenmeyer flask, six feet of rubber tubing, rubber band, ring stand, one hole stopper, and six inch glass tubing bent in the middle at a right angle. This demonstration requires the use of an electric fan, but Miss B has one in her room.

"How Does Oxygen Take Part In Chemical Change"[4] is Mr. C's chosen topic for his demonstration. In preparing the following list of required material Mr. C has the equipment file before him and indicates the case number beside

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[3] Victor C. Smith and Gilbert H. Trafton, Enjoying Science, p. 115.

[4] Victor C. Smith and Gilbert H. Trafton, Using Science, p. 123.

each item: test tube, rubber stopper, six inch glass tube, twenty-four inch rubber tubing, ring stand, clamp, manganese dioxide, potassium chlorate, Bunsen burner, gas collecting bottles, glass plates, trough, steel wool, magnesium ribbon, sulphur, deflagrating spoon, splint, litmus paper, and forceps.

The teachers check the three lists for any conflicts. They find that both Miss B and Mr. C require a ring stand, and there is only one available. However, in comparing the lists of the three teachers, it is evident that Mr. C would need the use of the demonstration desk and could use the support rod incorporated therein, thus making the ring stand available for Miss B.

The portable laboratory is then moved into Mr. C's room. The cases containing the chemicals and the chemical accessories are removed from the desk and placed on a nearby table where the contents will be easily accessible while conducting the demonstration. The remaining two cases are placed on chairs and opened.

The material required by Miss A and Miss B is removed from the cases and carried to their respective rooms where it is placed on a table and set up ready for use. First, however, it is necessary to cut and bend the glass tubing to the desired length and shape. This must be done at the desk where a Bunsen burner is available.

Mr. C sets up the apparatus for his demonstration on the laboratory desk, but he does not remove the chemicals from their cases until they are needed. All cases are kept locked when not in actual use.

The next day after the demonstrations are completed, all the apparatus is dismantled, cleaned, and returned to their respective places in the cases. The cases are locked and returned to their spaces in the demonstration desk which is then moved to a corner of the room where it will be out of the way. Miss B checks all this and makes notations on the proper cards in her file of any breakage. She also notes the breakages on the requirement list submitted by the teachers which she will accumulate for future reference. These lists will be invaluable for determining what new apparatus is most needed and for determining the quantities of supplies to be kept on hand.

It is realized that every teacher or group of teachers can and will develop their own techniques for operating this portable laboratory. However, if it is to be successful, it will require the earnest cooperation on the part of every science teacher. The portable laboratory cannot take the place of a well-equipped laboratory, but it must be kept in mind that this project was designed as an attempt to meet a need for improving the teaching of science in schools where, for economic reasons, better facilities cannot

be provided.

It is evident that the use of this laboratory can be an effective means of developing student responsibility in using and caring for equipment and supplies. No elaborateness is needed upon this particular obligation of education.

It is apparent, too, that planning and cooperation on the part of the entire faculty could result in more effective use of the portable laboratory. Cooperation and integration can be an experience of the students if science, mathematics, art, and manual training teachers work out problems together on various projects. English is functional in every undertaking, and every member of the faculty is responsible for making it functional in all communication, remembering that communication includes writing, speaking, listening, reading. And effective communication depends upon and in turn inspires and makes possible logical thinking, a prime objective of science.

Summary. The science teacher who is vitally interested in science should be responsible for operating and caring for the laboratory. Successful use as an instrumental means of improving science instruction will be determined by the efficiency and the effectiveness of planning and of performing certain involved duties.

Planning and cooperation on the part of the entire faculty could result in more effective use. Working together on projects involving science, mathematics, art, shop can be a worthwhile experience in cooperation and integration, an essential part of education. English is a significant part of all projects. Effective communication (which includes reading, writing, speaking, listening) is an essential part of everything. All success is directly dependent upon it. Therefore every teacher is obligated to make it function as effectively under all circumstances as the student is capable. These four phases of communication - reading, speaking, writing, listening - stimulate, and are in turn dependent upon, logical thinking, a prime objective of science teaching.

CHAPTER V

OBLIGATION OF THE ELEMENTARY SCHOOL

Great emphasis has been placed upon the role the elementary school plays in imparting to children the ideals and aspirations of the society in which they are to take their place. Giving them a science readiness is a major consideration in fulfilling this role.

THE SITUATION

Successful cultivation in the secondary scientific field becomes a surety when the elementary school has prepared the way. This obligation cannot be escaped. Yet science as a subject is perhaps the most neglected of all content areas in the elementary school. Although there are many contributing factors to this situation, none of them is insurmountable. Some of these problems are discussed in a recent issue of The Science Teacher:[1]

> The problem of finding time for science instruction.
>
> The problem of introducing a new subject.
>
> The problem of space in overcrowded classrooms.
>
> The problem of learning the content.
>
> The problem of suitable textbooks, courses of study, and supplementary reading material.

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1. Dwight E. Sollberger, "Aids to Elementary Science Teachers," The Science Teacher, Volume XV, Number 4 (December, 1948), p. 174.

It is obvious that there are many other problems to solve but those listed above appear to be widespread.

> A report from advisors to President Truman on Science and Public Policy takes occasion to emphasize the need for more and better science teaching for all. The conviction is spreading that if 90 per cent of our citizenry knew more about the workings of the human body, we would have a healthier community; that if 90 per cent of our people knew more about the crust of the earth, we would find it easier to conserve our dwindling natural resources; that if 90 per cent of all men and women were to understand better some of the facts of evolution and some of the principles of cultural development, there would be less prejudice and tension in the world. The time will come when science, like the three R's, will be accepted as basic to every individual's education.[2]

THE FUNCTION AND PURPOSE

There is a direct relationship of science to the major goals of education. The function of science in the elementary school is to make the world more intelligible to the child and to equip him with a way of thinking and a method of problem solving. Generally speaking, the fundamental purpose of teaching science is to contribute to the development of desirable social behavior. The primary concern is to aid children in using scientific procedures and information as a means of understanding their environment, of dealing with problems that arise, and of developing ways

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2. Morris Meister, "Outlook in Science Education," The Science Teacher, Volume XV, Number 3 (October, 1948), p. 106.

of thinking and acting that will contribute to the betterment of living.

The major purposes of teaching science in the elementary school are:[3]

> To help children develop concepts, principles, and generalizations which will be of value to them in understanding and solving their problems.
>
> To help children cultivate scientific attitudes, such as critical mindedness, willingness to seek and act upon reliable evidence, intellectual honesty.
>
> To help children acquire or develop a scientific method of work, including such elements as intelligent planning, careful observation, and the drawing of warranted conclusions.
>
> To help children explore new avenues of interest which will lead to the satisfaction of discovery.
>
> To help children acquire those skills and techniques necessary to gain further information, such as reading science content with understanding, making accurate observations of events, and performing various science activities.
>
> To help children develop social attitudes and appreciations needed in a democracy, such as growth in social behavior and willingness to assume their place in present and future society.

Experiences in science at the elementary level should lead to the attainment of these goals. These cannot be achieved by the mere reading of science materials or the memoriza-

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[3] A Guide to Teaching Science in the Elementary School, pp. 1-3.

tion of science concepts. Rather, children should be led to discover them by carrying out many activities in which problems are identified, probable solutions planned, results verified, and conclusions reached on the basis of the data. This method of discovering the truth, the scientific method, should become habitual in all situations.

THE NATURE OF THE EXPERIENCES

The teaching of science is a way of giving the student a "method of thinking."[4] The learning process is essentially "reflection upon experience" in search for "meaning." The heart of the teaching, whether in the textbook or in the mouth of the teacher, is explanation. The outcome, the learning product, is a new understanding, a new attitude of intelligence toward the present environment or toward the historical past, or a new principle to be employed in trained thinking derived from the study of one of the organized sciences.[5]

Science in the elementary school does not purport to develop laboratory workers or research scientists. Science for the elementary child is a part of his everyday

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4. Henry C. Morrison, The Practice of Teaching in the Secondary School, p. 9.

5. Ibid., p. 180.

living. It is impossible to exclude science experiences from the lives of normal children. The children's science experiences embody basic ideas which characterize all science in every age. They promote a type of total growth that is held desirable in young children and, to a high degree, the aims of science teaching are identical with the total aims of the lower elementary school.

Science being an integral part of the whole environment must be made meaningful to each child in the elementary school; therefore, learning in science must become an integral part of the school curriculum. The science program must be balanced with respect to all phases of the natural environment and planned as a functional part of the whole curriculum. By so doing it will give meaning, enrichment, and added significance to other areas of learning such as safety and health, the social studies, mathematics, the language arts, and the fine arts.

In order that a science program may be balanced, experiences should be planned in the six content areas of science - the earth as a part of the universe, the earth and its changing conditions, matter and energy and their susceptibility to change, conditions necessary to life, living things and their activities, and man and his environment. Problems often cut across all of these areas. However, the teacher should take care that no area is neglected.

Science experiences often constitute an aspect of the unit of work, or the integrated phase of the program. When the child is studying community life of former times or community living in distant regions, a comparison of plants, animals, and other natural resources would be appropriate.

Individual interests in science should not be overlooked. A child should be allowed to pursue his special interests during his free time. These interests may lead to the development of desirable hobbies and eventually lead to life interests.

Science in the elementary school should be personalized and kept close to the immediate interests of the child. Many applications of a principle must be experienced before a generalization can be satisfactorily drawn or a principle formulated. Science study is full of doing, observing, comparing, experimenting, obtaining first-hand experiences. It is by no means a "bookish" subject. A science textbook, however, has a large part to play as a guide to doing, as one source of reliable information, and as a means of developing new interests.

Science textbooks should not be used for assignment-study-recitation type of work. To derive full value from the books, the teacher should work with the pupils much of the time. Teacher and pupils together participate in the activities and follow the new fields opened up for study. The

material in the textbooks is intended for basic instruction. It will need much explanation and direction by the teacher if it is to function in the manner intended. It is necessary to build readiness for the concepts to be presented. Emphasis should be placed on concept building. Sufficient time should be taken to develop basic ideas through experiments, comparisons, and discussions from the material studied in the textbooks and reference books.

Experiments and demonstrations provide for an important phase of science learning. As the pupils carry out simple and practical experiments, they are learning far more than the facts that can be stated as conclusions. They are learning to seek evidence, to withhold judgment until facts are assembled, to modify conclusions in the light of new evidence. Many facts and concepts in science can be learned more effectively by seeing and doing than by reading alone.

RECOMMENDED APPLIANCES AND SUPPLIES

The experiments and demonstrations should be practical and involve only the simplest equipment and materials. Some demonstrations can be made with the material at hand, but there are many that require additional equipment. The selection of the apparatus and supplies incorporated in the following lists was largely determined from the Florida

State Adopted Science Textbooks[6] used in the elementary grades one through six. No attempt was made to cover the entire field. All the materials needed to conduct the recommended experiments and demonstrations are tabulated and organized in separate groups, as follows:

List 6 - Demonstration Equipment from Science Supply Company. The materials shown in this list (page 70) are of a special nature and usually must be obtained from a science supply company. The prices shown were taken from current issues of science equipment catalogues.

List 7 - Miscellaneous Equipment and Supplies. The miscellaneous supplies given in List 7 (page 71) are commonplace but necessary items which can be obtained easily locally.

List 8 - Desirable Equipment. The apparatus and supplies as shown on the preceding lists are considered adequate for conducting the essential demonstrations in connection with the teaching of elementary science. However, there is other equipment which, if the school's budget will

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6. Warren Knox, et al, The Wonderworld of Science, Books One, Two, Three, Four, Five, and Six.

warrant it, would be desirable for introducing other fundamental scientific concepts and for opening new avenues of interest. List 8 (page 72) shows some of this desirable apparatus as well as the equipment necessary for conducting some of the experiments recommended in the textbooks although it has been intentionally omitted for the purpose of economy.

List 9 - Equipment and Collections That Can Be Made by Pupils. This list (page 72) shows some of the simpler apparatus that can be constructed easily by the pupils at a very low cost. A rock and mineral collection accumulated by the pupils themselves would have great value as a learning experience. Any savings effected in the above manner can be utilized toward the purchase of more expensive but desirable equipment, such as a good microscope. A good microscope is one of the most essential pieces of equipment used in teaching science.

Care of equipment is important as it will become damaged or misplaced unless properly stored. Every piece of equipment should have a definite place in which to be kept when not in use. Simple storage cases or boxes may be made easily by the pupils for this purpose.

LIST 6

Demonstration Equipment from Science Supply Company

Quantity	Description	Cost
1	Aquarium	$ 4.00 up
1	Balance, Spring	1.50
1	Balance	6.00 up
2	Battery Jar - 1 quart	1.50
1	Battery Jar - 1 gallon	1.40
4	Beakers - 400 cc	.80
6	Bottles, wide mouth	.35
1	Clamp, burette	.50
2	Clamp, test tube	.24
4 oz.	Copper Metal, .01" thick	.35
1 pkg.	Corks, assorted	.50
1	Cork Borer	.85
8	Cover Plates, 5"x5"	.48
1	Compass	.75
1	Door Bell	1.00
3	Dry Cells	1.50
1	Electric Hot Plate	3.00
2	Flask, Erlenmeyer, 500 cc	.70
1	Funnel, 75 mm	.50
1	Glass Rod and Silk	1.25
1 lb.	Glass Tubing, 6 mm diameter	.60
1	Globe	15.00
1	Hard Rubber Rod and Fur	1.60
1	Insect Net	2.00
1 can	Iron Filings	.35
1	Jack Screw Model	.85
1	Lens, concave	.50
1	Lens, convex	.50
2	Light and Socket, miniature	.70
1 vial	Litmus Paper, red	.10
1 vial	Litmus Paper, blue	.10
1	Lodestone	.30
2	Magnet, bar	1.50
2	Magnet, horseshoe	1.15
1	Magnifying Glass	1.15
1	Microscope	20.00 up
1	Mirror, plane	.15
1	Motor, electric	2.50
1 set	Pulleys, set of 3, single, double, triple	1.60
1	Prism	.85
1	Push Button	.15
1	Pump, air	1.50
1/2 lb.	Rubber Stoppers, assorted	.75
5 ft.	Rubber Tubing, 5/16"	1.00
12	Rubber Balloons	.30

LIST 6 (Cont'd)

Demonstration Equipment from Science Supply Company

Quantity	Description	Cost
1	Support with 2 rings	$2.25
1	Switch, knife	.20
1 doz.	Test Tubes	.33
1	Thermometer (Fahrenheit-Centigrade)	1.45
1	Tuning Fork "C"	1.00
1 spool	Wire, copper #36	.30
1 spool	Wire, piano #6	.15
1	Wire Gauze (Asbestos Center) 4x4	.15
1 lb.	Zinc Metal Sheet	.60
Total		$87.80

LIST 7

Miscellaneous Equipment and Supplies
(Can be procured locally)

Quantity	Description	Cost
1 qt.	Alcohol, denatured	$ .85
1 qt.	Ammonia, household	.15
1 doz.	Candle, small	.25
1	File, small triangle	.10
6	Flower Pots	.60
1 roll	Friction Tape	.10
1	Hammer	1.00
1 pt.	Hydrogen Peroxide	.15
1 oz.	Iodine	.25
1 box	Modeling Clay	.25
1 lb.	Nails, assorted	.15
2	Pans, shallow	.30
1 pair	Pliers, combination	1.00
1 pkg.	Sand Paper	.10
1 pkg.	Salt	.05
1 pkg.	Sealing Wax	.15
1 pair	Scissors	.50
1	Screw Driver	.10
1 box	Soda, baking	.10
1 box	Soda, washing	.15
1 ball	String	.10
1 lb.	Sugar	.10
1 pair	Tin Snips	1.00
1 pt.	Vinegar, white	.10
Total		$7.60

LIST 8

Desirable Equipment (Optional)

Quantity	Description	Cost
1	Aneroid Barometer	$ 7.50 up
1	Dissecting Set	1.75
1	Dynamo and Motor	7.50
1	Flint and Steel (Fire-Making Outfit)	1.15
1	Force Pump, glass model	1.85
1	Lift Pump, glass model	1.85
1 set	Microscopic Slides, prepared	7.50 up
1	Primitive Fire-Making Outfit (Bow)	1.75
1	Telephone Station (2 way)	8.00
1	Water Wheel (Model)	13.50
Total		$51.85

LIST 9

Equipment and Collections That Can Be Made by Pupils

Description
Terrarium
Sand Box
Incline Plane
Cases for Storing Equipment
Rock and Mineral Specimens from Local Environment
Plant Presses
Insect Cages
Boxes for Raising Seedlings

Summary. Science is the most neglected area in elementary education although science aims are very similar to the total aims of the elementary school. Moreover, the elementary school must accept its responsibility for science readiness through a balanced program that will lead to the development of scientific thinking. Individual interests are a significant part of the program.

At present prices the simple equipment necessary for the experiments and demonstrations could be procured for $93.00. If feasible, there is other equipment that is desirable although not essential, and equipment and collections made by the pupils at no cost hold a prominent place among the necessary supplies. *All the materials needed to conduct the experiments and demonstrations recommended by the Florida State Adopted Science Textbooks are given in the lists incorporated in this thesis*.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary. This summary reveals facts in clear outline. It is through scientific thinking that conclusions are reached.

Presenting the Problem. Since the purpose of this project is the development of a portable laboratory whereby the teaching of general science in a junior high school can be improved, designing the demonstration desk and determining the types of appliances and the kinds of supplies which are to be used with the desk are the principal involvements.

By "portable laboratory" is meant a special demonstration desk mounted on casters. The complete unit will have facilities for bottled gas and electricity, special service fittings for the apparatus in the desk, and special drawers for storing apparatus and supplies.

In selecting the apparatus and supplies, there has been considered the Florida State Adopted Science Textbooks, practical demonstrations involving simple materials, and a cost within the price range of the average school.

More effective teaching would result if suitable demonstration equipment were available. Research and investigation have revealed that science is ineffectively taught at the present.

Society is obligated to supply materials for effective teaching that the schools as an agency of society may improve that society. Accurate observations from which conclusions may be drawn furnish a concrete means of developing the scientific method as a way of thinking.

Understanding the social significance of science rather than descriptive knowledge about the results of scientific development should be a chief aim. Science as a way of thinking and its social control as a force for good should be the real concern. This means that the science program will be concerned with the contribution science can make to the change in natural environment, in social environment, and in intellectual life. Without the connection of science with social practice, students get little understanding of the forces that make and remake human society.

To be functional, science must possess reality. Therefore laboratory experience is essential to scientific education.

A "portable laboratory" would provide for this need. It is within the reach of average schools. It would furnish motivating power, develop further interests, and develop scientific thinking for social good. Development of the scientific attitude is mandatory in this atomic era, and directive force toward that aim must be supplied.

Review of Literature. Differing points of view account for the emphasis upon various objectives of science. Educators advocate that each school form its own objectives in light of the school's philosophy. However, the Florida State Department of Education believes suggested purposes and functions are helpful and maintains that all science activities should provide learning experiences of progressively increasing complexities.

Since science will play a significant role in the social, economic, and political phases of the new era, it is important that science teachers understand what is desired in the development of young people who study science. Broad objectives may be expressed in a few comprehensive principles.

During the junior high school years science studies should be related to the student's life.

Education today seeks to meet the needs of all youth. In meeting these needs there are both differences and common qualities to be considered. One of the common educational needs is the influence of science on human life. Then the teacher of science is obligated to provide for differences in a cooperative undertaking of teachers and administrators.

Science can make significant contributions to newer educational trends - developing democratic living, community life, family relations, vocational guidance, health, recreation.

The work to be done in attaining an objective may be termed a "function." Experiences are means by which aims are attained. Putting value in evaluation will aid in choosing experiences for desired results.

Recently leaders in the scientific field have realized their social responsibility. Science can make a contribution to the general education of all youth and promote a type of total growth.

Functional experiences enrich science teaching. Dramatizations, field trips, reading, collections, visual aids, clubs, experimentation are enriching.

Then science is a means of making other subjects functional. All speaking and writing is English. Art and science influence and implement each other. A need for solving scientific problems brings mathematics into play. All associations involve civic responsibilities and socialization.

Knowing and using community resources enriches the science program. To understand the community is to understand the natural and social forces that have operated to make it what it is. Understanding the principles which create the problems is important as well as understanding the principles that could correct undesirable situations.

Every community possesses natural resources. Welfare is as dependent upon using these resources wisely as it

is upon the resources themselves. Soil, wild life, forest lands, water, mineral deposits, industrial developments are typical resources. Utilizing these resources for the welfare of mankind is important in a democracy. The great test of democracy will be determined by its ability to make adjustment to the impacts of science.

The Portable Laboratory. The portable laboratory, a special demonstration desk, would be instrumental in improving the quality of science teaching. The desk is so designed as to provide ample working space and at the same time hold all necessary demonstration apparatus without crowding. The service equipment built in the desk would aid in speeding the demonstration, so necessary both as a time element and as a factor in preserving thought continuity. (Figure 1)

The top of the desk is to be constructed of plywood and covered with black laboratory enamel. (Figure 2) The frame, to be constructed of welded steel, provides for lightness and strength. (Figures 3 and 4) The top is so fastened to the frame as to avoid metal on top of the desk. Removable cases provide ample space for installation of service equipment and for supplies. (Figures 5, 6, and 7) The cases are to be made of plywood.

Estimates on material for construction of the cases without the compartments amount to $20.00. The estimated cost of the cases with compartments is $65.00. The total estimated cost of the desk, exclusive of the cases, is $98.00.

An outstanding feature of the demonstration desk is the provision of gas which makes possible the use of a Bunsen burner, the most used and most necessary piece of apparatus in a laboratory.

The recommended appliances and supplies were determined largely from the Florida State Adopted Science Textbooks used in junior high schools. Five lists include laboratory accessories, demonstration equipment, miscellaneous equipment and supplies, and desirable equipment.

Figure 7 shows a suggested plan for the necessary compartments for storing the chemicals (List 1). This allows sufficient space for liquid and crystal chemicals, for larger solid chemicals, and for miscellaneous supplies.

The laboratory accessories (List 2) are necessary in conjunction with using the chemicals. These should be arranged in a separate case.

The demonstration equipment (List 3) is essential for special demonstrations. Such items as the microscope and the triple beam balance should be kept in the cabinet section of the desk. Other items, kept in the boxes in which supplied, should be stored in one of the cases.

The miscellaneous supplies (List 4) should be stored in one of the cases. Included in this list is a pail for catching waste water under the sink and a stone jar for holding used chemicals.

List 5 enumerates equipment that, although not essential, is desirable for introducing other fundamental scientific concepts and for opening new avenues of interest.

The combined lists of supplies, exclusive of List 5, amount to $153.48.

The entire laboratory could therefore be constructed and equipped for a minimum cost of $320.00. Equipment for demonstration and experiment is a necessary part of science instruction. The learning situation is enhanced. Interest is stimulated. Truths are revealed. Scientific thinking is developed. The portable laboratory is within the financial reach of any school.

Techniques in Using the Laboratory. One person, preferably the science teacher who is vitally interested in science, should be directly responsible for operating and caring for the laboratory. Efficient use and effective distribution of apparatus will determine the success of the laboratory as an instrumental means of improving science teaching. This will involve numerous duties and require cooperation on the part of all teachers.

These duties will include keeping an inventory of all supplies and replacing depleted items, maintaining and repairing the equipment, preparing for laboratory and demonstration experiments.

As a cooperative undertaking science teachers will need to plan together that each may have the required materials and apparatus at specific times. This will eliminate conflicts and at the same time assure efficient use. All groups of teachers can develop their own techniques for gaining these ends.

Although the portable laboratory cannot take the place of a well-equipped laboratory, it can meet the need for improving the teaching of science in schools that cannot provide better facilities.

Using and caring for equipment and supplies suggests opportunities for developing student responsibility.

Planning and cooperation on the part of the entire faculty could result in more effective use. Working together on projects involving science, art, mathematics, shop can be an experience in cooperation and integration. English is a part of every undertaking, as effective communication is essential to all success. It is the direct responsibility of all teachers to make English functional by requiring the best of which the student is capable in reading, speaking, writing, listening. These four distinct

phases of communication stimulate and develop logical thinking, a prime objective of science teaching.

Obligation of the Elementary School. The elementary school cannot escape its obligation in preparing the way for science understandings. However, it is at the present the most neglected of all content areas although the problems involved in the situation are not beyond solution.

Science aims are very similar to the total aims of the elementary school, and science is related directly to the total aims of education. Science experiences should lead to the attainment of these goals.

A balanced science program will include six content areas - the earth as a part of the universe, the earth and its changing conditions, matter and energy and their susceptibility to change, conditions necessary to life, living things and their activities, and man and his environment. The experiences should begin the development of scientific thinking. Individual interests should not be neglected.

Simple equipment only should be used in experimenting and demonstrating. At current prices demonstration equipment could be purchased for $85.00. Miscellaneous equipment and supplies would amount to $8.00. If the budget would permit, other equipment amounting to $110.00 would add

to the enrichment of the course. Equipment and collections made by the pupils at no cost are a significant part of the scientific learning.

CONCLUSIONS

Science in a great number of schools is ineffectively taught. Since there is little or no laboratory equipment in numbers of schools, this deficiency is due principally to that situation. Many schools are, from a financial standpoint, unable to possess well-equipped laboratories. However, the portable laboratory, which would provide for demonstration and experiment, is within the financial grasp of any school.

Demonstration and experiment are imperative in meeting the objectives of science. For instance, one cannot develop skills in applications by working with common appliances unless he has equipment with which to work. Society is obligated to supply materials that more effective teaching may result and in turn improve that society. Accurate observations from which definite conclusions may be drawn develop the scientific method as a way of thinking.

It is essentially desirable that science be effectively taught. The need of all youth to understand the methods of science, the influence of science on human life, and the main scientific facts concerning the nature of the

world and of man was one of the ten "imperative educational needs of youth" which became the ground work of the curriculum in the American City secondary schools.

In fact, the teaching of science is of such tremendous importance that the educational program could with value be based on science. The welfare of man is dependent upon scientific knowledge and its application. The great test of democracy will be determined by its ability to make adjustment to the impacts of science.

A basic integration results from a thorough consideration of the basic purposes of education. Science has contributions to make to the basic purposes of education, to desirable social behavior in a democratic society of the atomic era. Science as a way of thinking and its social control as a force for good, is a real concern. It is most important that the elementary school accept its role in preparing the way for science teaching in the secondary school.

Laboratory experience is essential to scientific education since, to be functional, science must possess reality. It furnishes motivating power, inspires and develops further interests, reveals truths, develops scientific thinking for social good.

More effective science teaching is an imperative need. Laboratory experience is an essential part of this

teaching. A portable laboratory can make this experience possible in all schools. Directive force toward the development of the scientific attitude must, in this atomic era be supplied.

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